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TECHNICAL MEMORANDUM **CH2MHILL**

Next Steps: AMD Generation Mitigations

TO: Mary Kay Voytilla/USEPA

FROM: Jay Dehner/CH2M HILL
Jim Stefanoff/CH2M HILL
Bill Hudson/CH2M HILL

DATE: July 8, 1999

1.0 Introduction

This memorandum presents recommended next steps for further evaluation and development of mitigations to reduce the quantity and strength of acid mine drainage (AMD) from the Bunker Hill Mine. The need for this memorandum was identified at the last presumptive remedy workshop conducted in Spokane on March 2 and 3, 1999. It was at this workshop that the draft presumptive remedy documents were reviewed and discussed, and it was determined that two technical memorandums were needed to help develop next steps for evaluation of potential AMD mitigations. One memo was for stream diversions and one for the surface expression of the Flood-Stanly ore body. Because of many commonalties between the memorandums, it was decided to combine them into this single memorandum.

The draft presumptive remedy documents describe remedies for long-term management of the Bunker Hill mine water. These documents identified infiltration of surface water and groundwater into the Flood-Stanly ore body area in Milo Gulch and into the Inez Shaft area in Deadwood Gulch as significant precursors to AMD generation. The documents also presented conceptual designs, order-of-magnitude cost estimates, and cost/benefit analyses for diversion of the West and South Forks of Milo Creek.

This memorandum presents recommended next steps for further evaluation and development of these and other mitigations for reducing water inflow to the mine. These next steps are intended to provide sufficient information to determine if the mitigations should be incorporated into a site proposed plan and subsequent record of decision.

The following potential mitigations are discussed:

Milo Creek Diversions

- West Fork Milo Creek Around Guy Cave Area
- South Fork Milo Creek Above Confluence with Main
- East Fork above Existing Main Stem Diversion
- Existing Main Stem Diversion

Flood-Stanly Ore Body Surface Expression

- Guy Caves Capping
- Hillsides Above Flood-Stanly

Deadwood Creek

- Deadwood Creek Around Inez Shaft Area

Organization

This technical memorandum is organized as follows:

Section 1—Introduction
Section 2—Background and Status
Section 3—Recommended Next Steps

2.0 Background and Status

Recharge to the mine is a complex issue. Several researchers have studied the movement of groundwater and surface water into the mine over the last 25 years. Movement of groundwater and surface water occurs through a complex series of interacting systems including:

- Primary and secondary fault structures and bedding planes;
- Underground mine workings and explorations that intersect faults and bedding planes;
- Direct infiltration into caved areas of the mine;
- Milo and Deadwood Creek interaction with the above systems.

The presence of the mine has changed the groundwater gradient downward toward mine workings. The underground workings act as a groundwater discharge point, short-circuiting its original flow path toward discharge to creeks and the river. Surface water bodies that intersect natural and manmade (mine workings and explorations) channels have potential to contribute significantly to recharge within the mine.

The studies conducted over the last 25 years have been undertaken to define water inflow mechanisms to the mine and to develop strategies to control the acid mine drainage. Considerable information has been developed during these past studies. These studies have been reviewed and considered during the development of the presumptive remedy documents. This information can also be used to facilitate the next steps described in Section 3.

The following subsections provide brief summaries of the development status of each potential mitigation with respect to effectiveness and implementability. These and other criteria, including cost, will be considered further as each potential mitigation is evaluated. The Milo Creek diversions are discussed first, potential Flood-Stanly surface expression mitigations next, and the Deadwood Creek diversion last.

2.1 Milo Creek Diversions

West Fork Milo Creek around Guy Cave Area

Effectiveness. A conceptual design, order-of-magnitude cost estimate, and cost/benefit analysis was prepared for this diversion and presented in the draft presumptive remedy documents. The cost/benefit analysis showed this diversion to be effective at reducing long-term treatment costs on the basis of hydraulic load reduction and concluded with a recommendation for its construction. This cost/benefit analysis should be reviewed and updated once the hydrology evaluation currently being performed is completed because the treatment plant size and associated costs may change.

Additional West Fork Milo Creek field reconnaissance was conducted on three one-day occasions during the spring of 1999 to further evaluate citing the diversion and to gather more information on the connection between flow in the creek and in the mine. The attached memo entitled *West Fork Milo Creek Spring 1999 Observations* presents the findings. In summary the findings indicate significant and direct correlation between flows in the West Fork and flows of acid water entering the Stanly Cross Cut on 9 Level.

Implementability. The major implementation issues are location, access, and design detail. The location has been narrowed down to a several hundred-foot stretch above the location considered last fall. The specific location needs to be determined by digging and/or drilling into the stream channel to assess alluvium thickness, groundwater gradients, and infiltration potential. Piezometers and infiltration studies may be needed. Access would be by new cat track, built as an extension to the existing overgrown one which ends near the location considered last fall. Refinement of the conceptual design and cost would be made once a specific construction site has been chosen.

South Fork Milo Creek above Confluence with Main

Effectiveness. A trial diversion in this location was constructed and tested a few years ago. The diversion was found effective at reducing inflow to the mine. A conceptual design, order-of-magnitude cost estimate, and cost/benefit analysis was also prepared for this diversion and presented in the draft presumptive remedy documents. The cost/benefit analysis showed this diversion to be cost effective on the basis of hydraulic load reduction and concluded with a recommendation for its construction. This cost/benefit analysis should be reviewed and updated once the hydrology evaluation currently being performed is completed because the treatment plant size and associated costs may change.

Implementability. The major implementation issues are the same as for the West Fork and are location, access, and design detail. However location and access are better known due to the findings of the trial diversion. Some channel test pits and drilling may be needed to fine-tune the location and refine the conceptual design and cost estimate.

East Fork above Existing Main Stem Diversion

Effectiveness. This fork of Milo Creek, which is also known as the main stem, carries the majority of the water due to its relatively large drainage area which contains portions of the Silver Mountain ski resort. Bryson Trexler conducted a gain/loss study on this reach in 1974 and reported the stream to be losing water into the mine. Joel Hunt performed a dye study in 1983 and could not find conclusive data to support water loss to the mine. It is currently unknown if a diversion would significantly reduce infiltration. Additional studies may be needed to answer this question, and could consist of gain/loss studies, test pits and/or drilling in the alluvium, piezometers, and infiltration studies to further assess leakage to the mine.

This stream stretch, which does not overly the Flood-Stanly ore body, parallels the Cate Fault. Because this reach does not overly the Flood-Stanly, it is expected that water which did infiltrate would produce primarily a hydraulic load rather than an acid load at the treatment plant.

Implementability. Like the other Milo diversions, the major implementation issues are location, access, and design detail. The location would be determined via the effectiveness investigations needed to determine if this stream section loses significant flow to the mine. Access would require a new road up the stream channel. It is likely the design would be similar to the conceptual design already developed for the South and West Forks.

Existing Main Stem Diversion

Effectiveness. The existing Main Stem Milo Creek diversion project was constructed in 1998 as part of the larger Milo Creek rechannelization project. Observations made this spring runoff season show that although the diversion successfully diverted stream flow, the streambed downstream of the diversion had water flowing in it most of the time. The performance of this diversion should be reviewed and options evaluated to increase its effectiveness.

The Central Shoshone County Water District emergency water supply dam, which is downstream of the diversion structure, is another likely source of water infiltration to the mine. A pipeline from the main stem diversion is used to fill this dam with water. Whenever this happens the streambed behind and downstream of the water supply dam has water in it, increasing the potential for mine infiltration. Options should be evaluated to reduce the recharge of this water.

Implementability. An evaluation should be made of the existing diversion to better assess how it performed this year and to identify possible improvements. A plan for operation of the Central Shoshone County Water District water supply dam with respect to minimizing leakage to the mine is also needed.

2.2 Flood-Stanly Ore Body Surface Expression

Guy Caves Capping

Effectiveness. The Guy Caving area could be capped with a low permeability cover system to reduce infiltration of rain and snowmelt to the underlying mine workings. Because the cave area overlies the Flood-Stanly ore body, any water infiltration enters the ore body and contributes to acid generation and flushing of accumulated acid salts. The lower cave was filled in with mine tailings, but still does not drain out of the cave area. Additional waste rock is planned to be placed in the lower cave this year in such a way to facilitate a possible future cap. An attached memorandum entitled *Guy Cave Grading and Capping Concepts* describes preliminary grading concepts.

No estimates have been made on how effective capping systems would be, but a start would be to estimate the volume of direct infiltration removed based on the surface area capped and the average annual precipitation amount. The volume of water could then be converted to an average annual gpm inflow to the treatment plant, combined with a range of assumed water qualities, and then converted to annual treatment savings. This is a similar approach to the other cost/benefit analyses performed for the South and West Forks of Milo.

Implementation. The attached memorandum entitled *Guy Cave Grading and Capping Concepts* describes preliminary concepts. Additional evaluation is needed to expand these concepts into a conceptual design that can be cost estimated.

Hillsides Above Flood-Stanly

Effectiveness. The hillsides which overlay the Flood-Stanly ore body are steep and contain areas of dense vegetation, mine waste rock, and abandoned and buried portals. Because near-surface workings underlay portions of this area, there is a high potential for infiltration to enter the mine workings. It was found this spring during the Flood-Stanly in-mine reconnaissance that early-season snowmelt infiltrates into near-surface workings of the Utz and Homestake due to ground warming caused by exothermic AMD generation reactions. Infiltration reduction options for the hillsides include capping, grouting, diversion ditches, sub-surface drains, and mine backfilling. No estimates have been made on the effectiveness of these options, but an approach similar to the one described above for the Guy Caves should be taken in which estimated treatment savings are compared to costs to build and operate the mitigations.

Implementation. Implementation issues will be developed as possible mitigation techniques are considered. Implementation challenges will primarily be the result of the steep, rocky, and unstable terrain. One challenge will be quantifying which portions of the hillsides to prioritize, because it may not be cost effective to implement mitigations over the entire area.

2.3 Deadwood Creek

Deadwood Creek around Inez Shaft Area

Effectiveness. In 1974 Bryson Trexler conducted a temporary diversion of Deadwood Creek over the Inez Shaft using a section of metal culvert pipe. He reported the diversion was effective in reducing flows from the west side of the mine. Kathleen Hampton in her 1985 thesis reported that mine personnel said the diversion was successful in reducing water flow on 10 Level. To further evaluate effectiveness a conceptual design and cost/benefit analysis is needed.

The conceptual design is expected to be very similar to the one already developed for the South and West Forks of Milo. Field reconnaissance in the Inez Shaft area is needed to locate the now buried shaft and other nearby workings. Water that infiltrates from Deadwood Creek enters the west side of the mine and contributes primarily to the treatment plant hydraulic rather than the acid/metal load. Therefore cost effectiveness is primarily based on savings resulting from reductions in hydraulic load.

Implementability. The major implementation issues are the same as for the Milo stream diversions, being location, access, and design detail. The general location is already known based on Trexler's work, and access should be fairly good due to the work done to remove the Arizona mine dump. Some channel test pits and drilling may be needed to fine-tune the location and develop the conceptual design and cost estimate.

3.0 Recommended Next Steps

Due to the complexity of water infiltration to the mine and the potential high costs to investigate, design, construct and operate mitigations, a phased approach is recommended for further evaluating the problem and determining appropriate solutions. This section presents a first phase of evaluation where existing information is summarized and combined with general onsite reconnaissance to develop a conceptual design, order-of-magnitude cost estimate, and cost/benefit analysis for each mitigation described in Section 2. This level of detail is needed to make go/no-go decisions on whether to include the various mitigation options in a site remedy. The next phase of development for each diversion which survives this first phase of screening will be either pre-design or design, depending on information needed.

Of the mitigations described in Section 2, all but two require conceptual designs, order-of-magnitude cost estimate, and cost/benefit analyses to determine if they are cost effective. The two that do not are the West and South Forks of Milo diversions because this information was already developed and presented in the draft presumptive remedy documents.

3.1 West and South Forks Milo Creek Diversions

The next steps for these diversions focus on fine-tuning the locations, access, and construction details, which are not needed for developing the proposed plan, and could be done latter as pre-design or design activities. This should involve field explorations of recharge and test pits in the alluvium to evaluate thickness and depth to bedrock, and possibly drilling to determine vertical ground water gradient and the edge of the mine's cone of depression. Tracer tests should be considered for confirming in-mine flow paths for infiltrated water. This would help site underground monitoring locations used to track effectiveness of the diversions.

Because of the West Fork's close proximity and direct hydraulic relationship with the Flood-Stanly ore body and the Guy Caves, the West Fork diversion will be included as appropriate in the evaluation of the Flood-Stanly mitigations.

3.2 East Fork Milo Creek

The first need is to determine if there is potential for a diversion to be effective at reducing inflow to the mine, and the first step is to determine if there is significant leakage from the creek into the mine. This is what Trexler and Hunt attempted to determine in their studies. Trexler concluded that there was, but Hunt could not support Trexler's findings.

Step 1—Independent Review of Trexler and Hunt Studies

Because Trexler and Hunt came to differing conclusions on whether there is significant leakage from the East Fork of Milo Creek to the Mine, the first step is to review their work and to make independent assessment of their findings.

Step 2—Preliminary Cost/Benefit Screening

If the independent review concludes that infiltration is likely, then it is recommended that a preliminary cost/benefit analysis be conducted to assess what level of infiltration is needed to offset estimated diversion costs. This preliminary cost/benefit analysis would be performed prior to implementing possibly costly field investigations designed to further evaluate infiltration. The analysis would involve estimating capital and O&M costs for the diversion, and using these costs to back out how much clean water would have to be kept from the mine in order to save these costs in downstream mine water management systems, such as collection, conveyance, and treatment. This amount of water reduction would be the bench mark for assessing whether significant leakage to the mine occurs in this stream reach. If this amount is considered unlikely to infiltrate, then the following steps are not needed.

Step 3—Design Field Investigations

If it is determined in Step 2 that infiltration reductions may be cost effective then additional field investigations should be conducted to quantify where and how much infiltration is occurring. These could consist of stream flow gain/loss studies, piezometer studies, infiltration studies, and test pits to assess the alluvium thickness and water flow rates. Plans to conduct these studies will be developed in this step. This step would also include a review of all applicable mine and geologic maps to determine proximity to underlying workings and fault locations.

Step 4—Execute Field Investigations

The field investigations developed in Step 3 would be implemented in this step.

Step 5—Data Assessment and Quantification of Leakage

The next step would be to assess the data from the studies and make a determination on the amount of leakage to the mine.

Step 6—Final Cost/Benefit Screening

Once it is determined how much and where leakage to the mine is occurring, then the final step would be to develop a conceptual design, an order-of-magnitude cost estimate, and a cost/benefit analysis comparing abatement capital and O&M costs to AMD management savings. The approach would be similar as done for the South and West Forks of Milo.

3.3 Flood-Stanly Surface Expression

The two potential mitigations for reducing water infiltration through the surface expression of the Flood-Stanly ore body are capping of the Guy Caves area and reducing infiltration through the hillsides which overly the ore body. Many of the next steps are the same for each and can be combined.

Step 1— Develop a map that locates the surface expression of the ore body and areas of interest for reducing infiltration. Also summarize findings from previous research and studies.

Step 2— Identify infiltration mechanisms and areas to the ore body.

Step 3— Estimate the infiltration and relative acid producing potential of each area and rank the areas.

Step 4— Determine abatement options for reducing water infiltration for the higher ranked areas.

Step 5— Gather additional information needed to refine the abatement options.

Step 6— Develop conceptual designs, order-of-magnitude cost estimates, and cost/benefit analyses for the highest-ranking options.

Step 7— Perform screening for inclusion in the site remedy using primarily effectiveness, implementability, and cost criteria.

Step 1--Develop Map and Summarize Previous Findings

Mapping. A map or maps showing the surface expression of the ore body and other information is needed to develop and evaluate mitigation options. Existing topographic mapping of the Milo Creek basin will be supplemented with the following information:

- Position of the Flood-Stanly ore body in terms of surface expression as well as at pertinent mine levels
- Primary and secondary fault mapping obtained from mine records correlated with geologic maps of the area
- Relative surface positions of pertinent underground mine levels
- Position of the Guy Cave area
- Surface water drainage courses and existing diversion structures for Milo Creek and its tributaries
- Surface location of key underground flow areas within the mine identified by the subsurface assessment that is currently underway

This mapping will be used in the identification and ranking process for inflow mechanisms to the mine. It is anticipated that this mapping will be periodically updated as new information becomes available.

Previous Findings. As mention previously, several researchers have studied the Milo Creek drainage basin and assessed AMD generation potential and flow mechanisms for recharge to the Flood-Stanly ore body. This step would develop a summary table of the research that has been performed and summarize the purpose and objectives of the study; the study area; locations, methods and accuracy of evaluations; key observations; and important conclusions of pertinent research. Copies of these studies are in the project library.

Step 2--Identify Infiltration Quantities, Mechanisms, and Areas

The source of water that infiltrates through the hillsides is rain and melting snow. In general the water seeps into the relatively permeable surface material until it encounters less permeable subsurface material, at which point it moves down-slope along the surface of this less permeable zone until it encounters a more permeable vertical pathway. These pathways could be fractures, faults, bedding plains, or mine workings. The water then moves through these pathways until it enters the mine. The key factors controlling infiltration to the mine are the quantity of water available for infiltration, the locations and depths of the relatively permeable surface materials, the locations and depths of the more permeable vertical pathways, and the locations and depths of the mine workings to which the water discharges.

Water Quantity Available for Infiltration. The quantity of water available for infiltration will be estimated by reviewing historical precipitation data. Precipitation data is available from the internet for the City of Kellogg. The average precipitation amount will be used, and this amount will be assumed to be evenly distributed through the study area, unless information is available to suggest otherwise. The importance of evapotranspiration rates will be considered and included if appropriate for vegetated areas. An implicit assumption will be that the water immediately infiltrates and does not run down the hillsides prior to infiltrating, unless information is available to suggest otherwise. Annual average quantities available for infiltration will be developed in terms of gpm/acre. These values will be used for the initial assessment of effectiveness, and will be refined if needed.

Location of Infiltration Pathways: Field Reconnaissance 1. The initial assessment of the locations and depths of the relatively permeable surface materials and the locations and depths of the more permeable vertical pathways will be made during an initial field reconnaissance. The initial field reconnaissance efforts will focus on observation of inflow mechanisms to the underground working of the mine from surface areas around the Flood-Stanly ore body, the Guy Cave area, and the West Fork of Milo Creek. The field reconnaissance will seek to characterize the accuracy of the mapping of important features performed in Step 1, and determine methods that could assist in providing further characterization and improve mapping accuracy. The field reconnaissance will also be used to assist in obtaining initial field information for the ranking and quantification of potential inflow areas to the mine.

Key field activities for the initial field reconnaissance are:

- Mark major fault position in the field using coordinates established from Task 1 mapping efforts and hand-held GPS unit. Make field observations on potential position revisions based on field conditions. Determine areas to consider accessing for future explorations based on potential for infiltration, method of exploration, and ease of access for field equipment that could potentially be useful in gathering additional field data for location of discontinuities and flow areas.

- Review fault positions at Milo Creek and its tributaries. Note stream flows where possible both upstream and downstream of faults and other areas of interest. Review potential locations for stream diversion structures and pipeline routing. Note the strike and dip of the rocks in the area.

- Observe the Guy Cave area. Walk the cave area and review field position relative to mapping. Observe surface structure of area, looking for infiltration areas and indications of potential flows. Observe area for signs of structural integrity and ability to cap/divert inflow from area.

- Observe general geologic and hydrologic condition of Milo Creek basin area in vicinity of Flood-Stanly ore body surface expression. Check flows within alluvial profile if feasible in selected areas.

- Review other areas determined from mapping task to have high potential for infiltration. This could include areas determined to have shallow mine workings, or other structural features that indicate potential for inflow to the mine.

- Observe and record flows from the Phil Sheridan raises and the open dill hole.

Field Reconnaissance Team and Coordination. Field reconnaissance activities will be coordinated with Bob Hopper. The reconnaissance team is expected to consist of the following people:

Jay Dehner, Reconnaissance Lead, CH2M HILL Geotechnical Engineer
Ken Green, CH2M HILL, Senior Geotechnical Engineer
Bill Hudson, CH2M HILL, Mining Geologist, Site Safety Coordinator
John Riley, Pyrite Hydrochem, Hydrogeologist
Dale Ralston, Uof I, Senior Hydrogeologist
Nick Zilka, IDEQ
Matt Germon, CH2M HILL

It is anticipated that the initial field reconnaissance will take place over the period of two to three days. Meetings will be held in the project office in Kellogg to review data and maps, make field observations, and discuss observations.

Health and Safety. Bill Hudson will serve as the Site Safety Coordinator (SSC) under the CH2M HILL Health and Safety Plan (HSP). Appropriate health and safety briefings will be held at the start of work, and all people entering the site will be under SSC supervision and will sign the HSP.

Documentation. Brief write-ups will be forwarded to Jim Stefanoff/CH2M HILL at the completion of each reconnaissance day, or as necessary. The write-ups will discuss the important findings relative to the reconnaissance objectives and will use format consistent with the Hanna Stope Reconnaissance Plan. A copy of field notes and any available marked-up maps or sketches will be attached to the write-ups. A reconnaissance report will also be prepared which summarizes the findings.

Step 3--Estimate and Rank Infiltration and Acid Generation Potentials

Based on the results of Steps 1 and 2, the infiltration and acid generation potential for each area will be estimated and ranked on the basis of the following:

- Potential recharge quantity to the mine in the vicinity of the Flood-Stanly ore body
- Level of certainty of mechanism and flows
- Access and ability of options to mitigate
- Additional data requirements for improving understanding of flow mechanism

Ranking of the flow mechanisms is intended to establish a general picture of what we know about the problem at this point in time. It is possible that additional field investigations will be necessary in subsequent phases of the work to adequately characterize the mechanisms and refine the ranking system. This ranking system will be used to focus subsequent tasks on those mechanisms that provide the greatest opportunity for abatement of inflow and subsequent AMD generation in the mine.

Step 4—Determine Abatement Options

Potential abatement options for the higher ranked areas determined from Step 3 will be identified in this step. The abatement measures will seek to divert, cut-off, or intercept surface water and groundwater from entering the mine. Some of the potential measures include capping systems, grouting systems, cut-off trenches and ditches, surface water diversions, horizontal or lateral drains, and vertical pump systems. Measures will be reviewed for applicability to the inflow mechanism and constructability. Conceptual sketches of potential abatement measures will be developed in an effort to determine what questions need to be addressed in the upcoming second field reconnaissance.

Step 5—Gather Additional Information: Field Reconnaissance 2

This second field reconnaissance will focus on developing site specific information needed to develop conceptual designs for the abatement options developed in Step 4. Reconnaissance activities are expected to be similar to the first reconnaissance but more focused on areas considered for a mitigation. This reconnaissance is anticipated to be another 2 to 3-day effort and the same reconnaissance team is expected to be used following similar protocol to the first.

Step 6—Develop Conceptual Designs, Order-of-Magnitude Cost Estimates, and Cost/Benefit Analyses

Conceptual designs will be developed for the higher ranked abatement options to sufficient detail for preparation of order-of-magnitude cost estimates. The expected level of detail is similar to that for the ones already prepared for the South and West Forks.

Step 7—Screening

Based on the results of Tasks 1 through 6, identified options for abatement of recharge to the mine will be evaluated, ranked, and screened on the basis of effectiveness, implementability, and cost. The cost/benefit analysis will provide basis for assessing cost effectiveness.

Step 8—Next Steps

Additional data requirements needed for pre-design and design will be summarized for the options which remain after screening. Activities that may be needed are additional field reconnaissance, test pits, piezometer installations and monitoring, infiltration tests, and other studies to provide design and construction information.

3.4 Deadwood Creek around Inez Shaft Area

Trexler's work indicates that a diversion of Deadwood around the Inez Shaft area has potential to reduce mine infiltration. The following next steps are recommended for determining the cost effectiveness of a diversion, and are similar to the steps already conducted for the South and West Forks of Milo Creek.

Step 1—Preliminary Screening

A preliminary screening should be conducted as a first step. An estimate of the annual flows in Deadwood Creek should be made. This could be done similar to the estimates made for the West Fork of Milo. Costs for the diversion could be estimated in relation to the South and West Fork diversions. Consideration would be given to costs for either lining a portion of the stream bed or plugging the shaft in lieu of a cutoff dam and diversion pipeline. A range of infiltration reductions could then be assumed and used in a cost/benefit analysis for clean water reductions to the downstream presumptive remedy components. Three possible outcomes exist:

Possible Outcome 1: The Diversion is Clearly Cost-Effective. If the preliminary screening shows the diversion to be clearly cost effective, then the diversion should be included in the proposed plan. Next steps would be pre-design and design steps consisting of final citing and design details, similar to those needed for the West and South Forks to fine-tune the locations, access, and construction details. Another construct/not-construct decision may be needed if these steps indicate the costs to be significantly more than used for preliminary screening.

Possible Outcome 2: The Diversion is Clearly Not Cost-Effective. If the diversion is clearly not cost-effective then no further evaluation is needed.

Possible Outcome 3: The Cost-Effectiveness is Uncertain. If the cost-effectiveness is uncertain then Step 2 is needed.

Step 2—Refine Effectiveness and Cost Estimates

Since Trexler's work in the early 1970s the shaft has become filled in or covered with stream debris and no longer visible. The shaft's exact location is needed to develop a more accurate cost estimate and determination of effectiveness. The approximate field location can be found using mine maps, existing surface features, and GPS probably with 50 to 100 feet. Other potential near surface workings in the vicinity should also be identified from the maps. A track hoe could then be used to probe the stream channel for the shaft and other workings, and to evaluate alluvium depth and depth to bedrock. Drilling may be needed to determine vertical groundwater gradient to select a diversion site. Once these steps are done a more accurate cost/benefit analysis could be performed.

West Fork Milo Creek Spring 1999 Observations

TO: Mary Kay Voytilla/EPA

FROM: Jim Stefanoff/CH2M HILL

DATE: July 8, 1999

This memorandum describes observations of flow in the West Fork of Milo Creek made during three one-day reconnaissance visits during the spring of 1999. These occurred on May 26, June 4, and June 8.

May 26 Recon

The first recon occurred on May 26, 1999. Bill Hudson and Jim Stefanoff hiked up the West Fork drainage above the Guy Cave area and made the following observations:

- Flow in all the Milo Creek forks was up due to the spring thaw, and it appeared that runoff was near seasonal highs
- Water was flowing down the steep cat-track access road which is the approach to the West Fork. The water was flowing down the east side of the road and in the east ditch. The water seeped into the ground below the Phil Sheridan raise (the eastern raise constructed in the West Fork drainage, referred to as Raise #2 in the Joel Hunt Thesis) and it had all seeped in by the time it reached the point where the road curved east. However, water channels in the road lower than that location suggest that it had flowed further in the past.
- The raise to the Phil Sheridan was full of water and water was overflowing the raise through the talus at the east end of the downstream berm. Water was also flowing from springs at the base of the berm. These were the sources of the water flowing down the road.
- Jim Stefanoff estimated about 250 to 600 gpm was flowing into the raise.
- There was no water flowing into the western raise or sign of previous water flow (Raise #1 in the Joel Hunt Thesis).
- Bill and Jim hiked to the Phil Sheridan Portal and observed an estimated flow out the portal of about 50 to 100 gpm. This flow dropped over the hillside and seeped in, with no sign of it reemerging.

A 9-Level mine water monitoring event was conducted on May 28. It was found that an unusual amount of mine water was coming out of the Stanly Cross Cut. The capacity of the 9 Stanly Cross Cut flume was exceeded, and the flow was estimated to be about 300 gpm. This is over 75 times seasonal base flow. The strength of this flow was strong, with a conductivity of 5,200 and a pH of 0.99. The bulk of the flow being measured was coming down an ore chute located just behind the 9SO flume and on the left of the drift (looking upstream), which has since been designated Stanly Ore Chute #2. Considerable flow was also coming down a chute behind the muck dam (the dam is located immediately behind the flume) on the right side of the drift.

June 4 Recon

The second spring 1999 field recon occurred on June 4. Bill Hudson, Matt Germon, and Jim Stefanoff first went underground on 9 Level and made flow measurements and measured pH and conductivity at the monitoring stations. Bill noted that the Stanly Cross Cut flows were visually lower than on May 28. The flows were estimated via transit time through a known cross-sectional area to be about 375 gpm (this or the May 28 flow estimate may be in error). The flume was not used because it had been dislodged from its location, presumably by high flows.

After making the underground measurements they hiked up the West Fork and found that the flow had dropped down to an estimated 100 - 150 gpm directly upstream of the raise. The raise was not overflowing anymore and there was no standing water, but the bottom, which was about 4 feet lower than the previously observed high water mark, was muddy.

June 8 Recon

The third spring 1999 field recon occurred on June 8. Mary Kay Voytilla, Nick Zilka, Dale Ralston, Bill Hudson, John Riley, Matt Germon, Jay Dehner, and Jim Stefanoff hiked up to the Guy Cave vicinity. Matt and Bill separated from the group and hiked into the Phil Sheridan to measure flows at the back of the drift coming from the two raises and from the drill hole. The rest of the group hiked up to the Phil Sheridan raise. Flow from the West Fork into the raise had stopped and the raise had dried. The group hiked up about 200 feet to the end of the cat-track location which had been a possible diversion location identified last fall. There was no flow in the West Fork at this location, but water could be heard running upstream.

Mary Kay, Jay, and Jim hiked up the stream bed for a total of roughly 1000 feet up to the bottom of a talus slope which entered the stream channel from the west. The stream gained flow along the way, with the biggest gain appearing in the first 200 feet from the end of the cat track location. About 200 feet up there was a location where the channel narrowed, and a rock outcropping entered the channel from the east. This may be the Katherine Fault, but no clear determination could be made. No accurate estimate of the flow in the streambed could be made along this reach because it was difficult to quantify due to the alluvium.

Bill and Matt reported that about 5 gpm was coming down into the Phil Sheridan from both the east and west raises, and about 5 to 10 gpm from the open drill hole.

Guy Cave Grading and Capping Concepts

TO: Mary Kay Voytilla/EPA

FROM: Jay Dehner/CH2M HILL

DATE: July 8, 1999

This memorandum summarizes my site visit with Bill Hudson to the Guy Caving area at the Bunker Hill Mine on June 17th, 1999. The purpose of the visit was to discuss grading concepts for the upcoming placement of waste rock from near Wardner into the Guy Caving area, and how the grading might interface with any potential future cover installations in the area.

Waste Rock Grading

Key points discussed with regard to placement of approximately 30,000 cubic yards of waste rock into the Guy Caving area include:

- *Waste rock placement should grade to drain surface water drainage out of caving area,* where possible.
- Bill would like to build access road into upper cave area for future access for capping and additional disposal.
- Road access for trucks needs to be limited to a grade of about 10% for backing in and dumping. Trucks will need turnaround area for backing into dumping area. From truck dump area, a large bulldozer will push and grade the material in-place.
- Limitations of road grade versus the steep existing grades of the cave area require that the waste rock access road switchback across the face of the lower caving area to place the fill.
- Cover grades for any future cover system will likely need to be flatter than what will be required to construct fill placement roads. Grades of 3 horizontal to 1 vertical are typical maximum for placement and covering of geosynthetic-type of cap, without the need for special design and construction techniques.

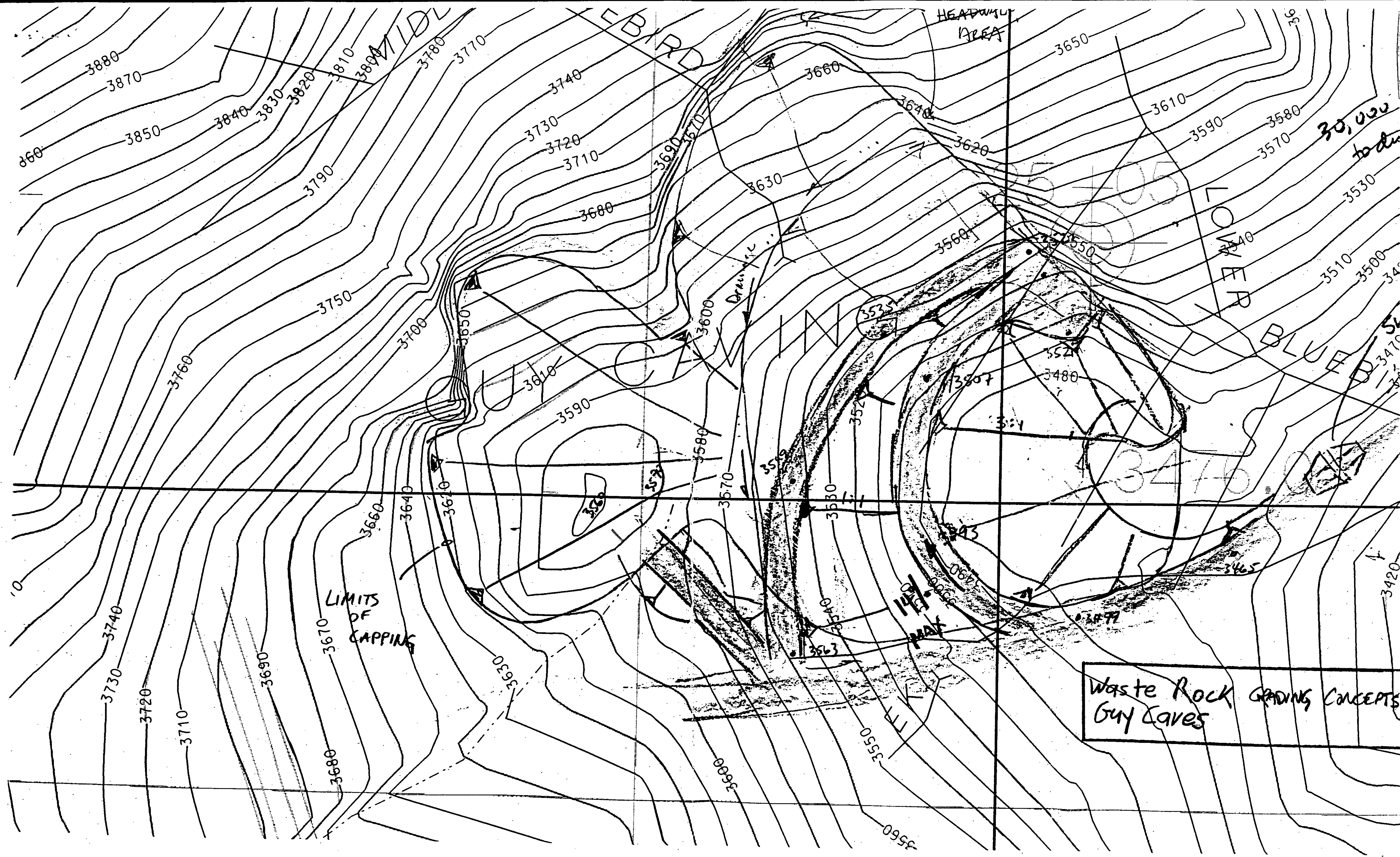
Using these grading criteria, a sketch of potential waste rock grading in the Guy Cave area was developed and discussed. A copy of the sketch is attached to this memo.

The sketch shows a two-tiered access road that switchbacks across the lower cave area, connecting to the existing cat road just below the upper cave area. The first leg of the access has a grade of 10% and an embankment slope of about 3H:1V to reach existing grade. A dumping/push platform is shown against the north side wall of the caving area. From the dumping platform, the access road is pushed in at a 10% grade up to the intersection with the existing cat road. This section of road embankment grades steeply (about 1H:1V) down to the lower switchback road and will require significant maintenance to keep open as this steepness is subject to sloughing. Note that this upper road section may cross portions of the large rock-block mass that has collapsed into the cave area. From the intersection with the existing cat road, a short access road will be punched into the upper cave area.

Capping Grading Concepts

After sketching up waste rock grading concepts, a visit to the caving area was performed to cross-check the concepts and review grading alternatives. Based on the site visit, the following ideas were developed for grading the site for future capping:

- The headwall of the caving area appears to be competent rock in a near-vertical configuration, in most areas surrounding the cave.
- Grading to fill the entire cave area to the top of the headwall does not appear practical or cost-effective.
- Potential exists to pull materials from upper cave area and grade down to lower. Actual excavation of upper area (to increase headwall) may be possible to reduce overall steepness of the cave area. Bill thinks headwall integrity extends well below what we can see at the cave area.
- Stair-step configuration (3H:1V slopes with short vertical benches) across cover is potential to create overall slope needed for cover and drainage.
- Drainage ditches and berms would need to converge to a collection point and carry stormwater runoff from cover area and drop into West Fork diversion discharge pipe. Note that these flows would need to be considered in sizing West Fork diversion piping.
- Drainage ditches and berms would also be constructed above the headwalls. These would also discharge into the West Fork diversion piping.


HEADWALL AREA
LIMITS OF CAPPING
1:1
3:1
14' MAX
Waste Rock GRADING CONCEPTS
Guy Caves